FIRST EVALUATION

uOttawa

January 18, 2012

Université d'Ottawa
Faculté des études supérieures et postdoctorales
University of Ottawa
Faculty of Graduate and Postdoctoral Studies

Mr. Nicholas Ali
306 – 589 Rideau Street
Ottawa ON K1N 6A1

Dear Mr. Ali:

The reports of the examiners of your doctoral thesis in Human Kinetics have now been received and I regret to inform you that your thesis must undergo **major** revisions in order to make it acceptable for the oral defence.

Enclosed, you will find a copy of the comments of the examiners; Dr. Daniel Benoit, Dr. Graham Caldwell, Dr. Michel Labrosse, and Dr. Edward Lemaire, which I believe will be useful during the course of your revision. Before proceeding with your corrections, I suggest that you discuss this with your supervisor. If you need additional clarifications, you may also contact your examiners. When completed, please list the changes made on a separate sheet and identify the corresponding page numbers in the original as well as in the revised version. Should you decide not to address some of the criticisms, it would be important to give the reasons for your decision in writing.

According to FGPS regulations, you will have to register for the **winter 2012** session (January-April) while performing your revisions. Please **complete and sign** the enclosed Graduate Registration form **including your classification (full or part time) and** send it by fax to the FGPS Registration and Records Section at 613-562-5992.

Five copies of your revised thesis must be submitted to the Faculty of Health Sciences by **April 30, 2012** for a re-evaluation by the same examiners.

Sincerely,

Ross Hastings, Ph.D.
Acting Dean

c.c. D. Benoit, E. Lemaire, B. Séguin, G. Caldwell, G. Robertson, L. O'Reilly, M. Labrosse, G. Rouhi, N. Carter

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FACULTÉ DES ÉTUDES SUPÉRIEURES ET POSTDOCTORALES

THESIS EXAMINER'S REPORT

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FACULTY OF GRADUATE AND POSTDOCTORAL STUDIES

NAME OF STUDENT	STUDENT NUMBER	DOCTORAL THESIS	MASTER'S THESIS
Nicholas Ali	5033260	☒	☐

DEGREE	ACADEMIC UNIT
PhD	School of Human Kinetics

TITLE OF THESIS
"Predicting Risk Factors of Non-Contact Anterior Cruciate Ligament Injuries During Single-Leg Landing"

NAME OF THESIS SUPERVISOR	NAME OF THESIS CO-SUPERVISOR
Dr. Gordon Robertson	Dr. Gholamreza Rouhi
NAME OF EXAMINER	**DEADLINE FOR SUBMISSION OF REPORT**
Dr. Edward Lemaire	December 19, 2011

INSTRUCTIONS FOR EXAMINERS

PART A: EVALUATION / Tick off the choice that best describes your evaluation of the thesis.
PART B: COMMENTS / Provide your comments for each of the topics listed.
PART C: RECOMMENDATION FOR A PRIZE / Indicate your decision and complete the attached form if recommending thesis for a prize.
PART D: SIGNATURE / Sign and date the form
PART E: DOCUMENTS / Return necessary documents.

PART A: EVALUATION

CRITERIA

DOCTORAL THESIS: The thesis must constitute a significant contribution to knowledge, embody the results of original investigation and analysis by the student and be of such quality as to merit publication.
MASTER'S THESIS: The thesis should demonstrate that the candidate is able to work in a scholarly manner and is acquainted with the principal works published on the subject of the thesis. Insofar as it is possible, the thesis should be an original contribution.

VERDICT

1	☐	**The thesis is accepted for the defence.** • The thesis meets the evaluation criteria listed above. • Required changes are limited to correcting occasional grammatical or spelling errors, formatting problems or to minor redundancies or omissions (e.g., transitional paragraphs, notes).
2	☐	**The thesis is accepted for the defence but must be revised AFTER DEFENCE.** • The quality of the presentation is acceptable and the necessary revisions will not have an impact on the defence. • During the defence, the jury will determine which revisions are necessary and who will be responsible for ensuring they have been completed and for approving the thesis.
3	☒	**The thesis cannot be accepted for the defence and must undergo extensive revision BEFORE DEFENCE to ensure it meets the above criteria.** • There are problems with the interpretation of results or the theoretical or methodological approach, but the thesis may meet the criteria if substantial changes are made. • The presentation of the thesis is still not acceptable (numerous grammatical or spelling errors, evidence of carelessness, etc.). In this case, the thesis is returned to the candidate to complete the required revisions, corrections and changes. The candidate must submit a revised version of the thesis to the examiners. The examiners must judge the changes satisfactory before the thesis can proceed to the defence stage.
4	☐	**The thesis still fails to meet the standards required for the degree.** • The work was not done in accordance with established methodology employed by the discipline. • The thesis does not exhibit the candidate's capacity to meet the scholarly standards required. • Even with extensive revision, the thesis would not meet the standards required for the degree. In this case, the candidate may be asked to withdraw from the program.

NOTE: Your feedback will have an impact on how the candidate prepares for the defence, the dean's decision if the jury is divided and the awarding of prizes. Please be sure to complete Section B regardless of your verdict.

PART II: COMMENTS

Please provide your comments on each of the topics below in a separate document. If the thesis is accepted for the defence (see verdicts # 1 and # 2, above), your comments will be sent to the candidate and the thesis supervisor without reference to your identity. If major revisions are required before the defence (see verdict # 3, above), a signed copy of your comments will be provided to the student, the supervisor, as well as to all members of the jury and the chair of the academic unit.

→ UNDERSTANDING OF THE SUBJECT MATTER
→ CONTRIBUTION OF THE THESIS TO ADVANCING KNOWLEDGE
→ RESEARCH METHODOLOGY
→ ANALYSIS OF RESULTS AND VALUE OF CONCLUSIONS
→ ORGANIZATION, WRITING STYLE AND PRESENTATION OF MATERIAL
→ REVISIONS CONSIDERED NECESSARY IN ORDER FOR THESIS TO BE ACCEPTED
→ GENERAL COMMENTS

Your comments and explanations are extremely important and will:

- help the student prepare for the defence or make necessary revisions to the thesis (if revisions are required before the defence, a signed copy of your comments is provided to the candidate, the thesis supervisor, as well as to all members of the jury and the chair of the academic unit);
- allow the dean of FGPS to make an informed decision if the jury is divided; and
- allow the FGPS selection committee to choose recipients of prizes and medals.

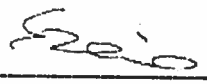
PART III: RECOMMENDATION FOR A PRIZE

Do you recommend this thesis for a prize?

☐ YES – Please complete the attached NOMINATION FOR THESIS PRIZE form.
☒ NO

The absence of a reply will be considered a NO.

PART IV: SIGNATURE

DATE December 5, 2011 SIGNATURE 

PART V: DOCUMENTS

Please return all documents by email to fssrecherche@uOttawa.ca or by fax to 613-562-5437 and send the originals in the enclosed self-addressed envelope to:

Assistant to the Vice-Dean, Research & Graduate Studies
Faculty of Health Sciences
Roger Guindon Hall
451, Smyth Road Room 3028
Ottawa ON K1H 8M5

(W. Edward Remaike

Nicholas Ali – Thesis Review

Overall

- Revise paragraph format
- Now much of the predictive nature of ACL injury is random and how much is predictable?
- The term "risk factors" is often used in a manner that leads the reader to question the appropriate use of this term. For example "To accomplish this a problem is defined and formulated to determine the instance where many risk factors, many forces, and other extreme conditions happen simultaneously to cause ACL failure." In my mind this includes environmental factors (ice, etc), footwear, medication, range of motion, balance, etc. More precise terms would be useful in many situations within the thesis.
- The first two papers try to build a rationale for an ACL research methodology, but this method was not used in the thesis. Therefore, should these papers be included in this thesis?
- Plantiflexion should be changed to plantarflexion throughout the document
- The word "gleaned" is used in the thesis. This can be changed, since the information is usually not "extracted from various sources" or "collected gradually and bit by bit"
- BW may be in N for paper 3 and Kg for paper 4 (Nm/BW*h). Please check and be consistent.
- Do not replace commas with dashes. For example. "statistics –not presented– one can observe" should be "statistics, not presented, one can observe"
- Since arms motion was removed from the task, this should be considered with discussing the results
- In paper 3,
    - Results must be clarified to indicate which results are linked to vertical, horizontal, or individual height analyses.
    - Results must be shown in tables for each height and distance condition (mean and SD)
- In paper 4,
    - The introduction talks mainly about the lack of literature but does not discuss the outcomes from the literature that does exist. This section needs to be rewritten to provide the reader with an overview of the existing literature on gender differences with single leg landing. This should cover both drop landing and jump to single leg lending since both topics are relevant. You can also discuss the overall findings studies on just males and just females studies.
    - What post-hoc statistical tests were used to support statement of significance in the results (ex., Females had significantly less ankle plantiflexion angle than males)?
        - Post-hoc analysis is needed to explore the differences between conditions and groups
    - What range was used for the work outcomes?
    - Bring all mean and SD outcomes into one table (easier for the reader to examine outcomes). Includes table 2, 4,6

        - The font size is small. Tables could be revised if font size can be increased, but put these revised tables beneath each other in the manuscript.
        - It would be useful to have female, male, and overall mean and SD data presented, since the focus of the paper is on gender differences
- Paper 5:
    - See Kernozek, Torry, et al (2005)
    - Various aspects of the validation steps on pages 128-129 are unclear.
        - Specifics of the subjects, data, and activity used for Anybody input should be presented.
        - This section combines methods and results. Separating these may help to solve the confusion for the reader.

Text edits

- Page 24: "This work also appraises the methodological rigor"
- Page 25: "revise "has been somehow patchy"
- FaunÃ is mispelled, check foreign language character sets.
- Page 27:
    - "side step cutting maneuvers, to name a few"
    - "view of ACL injury mechanisms"
- Page 29: "McConkey (McConkey, 1986) was the"
- Page 30: "As well, muscle activity across the ankle controls the position of the foot at landing, which most likely influence the loading at the ankle"
    - As well, muscle activity across the ankle controls the foot position at landing, which most likely influences ankle loads.
- Page 35: "Another, non contact method includes optical"
    - Rearrange paragraph to group contact and non-contact items
- Page 37: "Computational modeling has become popular partly"
- Page 37: Remove "(see for instance"
- Page 39: Reword "ACL injury research is a multidisciplinary field, since one need to consult with many disciplines in a single problem"

Content

- Page 25: "Nonetheless, the prevention of sport related noncontact ACL injuries today relies largely on the ability to screen at risk individuals and then modify through training the identified risk factor."
    - Screening for being at risk of ACL injury is not a common practice (i.e., foes not "rely largely upon)
    - Appropriate ACL at risk screening tools are not available
- Page 26: "are among the risk factors that can be modified through training"
    - Listed items are not risk factors
- Page 26: What is "hand searching", reading paper copies of journals? What journals were reviewed?
- Page 27: How did you determine that computing power was an obstacle for these studies? The choice to use slower computers does not mean that other computing options were not available.

- Page 27: What are the "the associated contributing risk factors"? What about the target activity and environment?
- Page 30: "that foot contact with the ground is an important risk factor in non-contact ACL injury"
    - Soccer players make foot contact with the ground with each step, typically without injury, therefore this risk factor statement should be reworded
- Page 31: "ground reaction forces (GRFs) cannot be transmitted effectively through the **bones to the ground**"
    - GRF vector is from the ground to the foot
- Page 31: "the trunk and pelvis position will have coupled effects on knee angles"
    - The knee angle may have effect on the pelvis and trunk …
- Page 32: "The position of the leg at the time of non-contact ACL injury displays tibial rotation, apparent knee valgus, foot pronation, and a relatively extended knee and hip
    - You did not "display" this information in the paper. What situation is being described here? More detail is needed.
- Page 34: "These are termed contact methods and have the advantage of simultaneously including many risk factors,"
    - How does an implanted transducer include risk factors?
    - All relevant muscles are typically not instrumented
    - Which forces?
- Page 36: "The major advantage of in vitro testing is its utilization of biological tissue for testing"
    - In vitro can be defined as "In an artificial environment outside the living organism", so testing biological tissue need not be involved.
    - Testing in-vitro is a disadvantage over in-vivo, but necessary
- Page 36: "In vitro testing also has the capability to simulate knee kinematics and muscle loads."
    - You could also use in-vivo data to drive a simulation
- Page 36: "Other challenges with in vitro studies using cadavers are the inability to simulate realistic muscle activation and the difficulty in obtaining repeatable results"
    - This is the same thought as the previous sentence.
    - Repeatability is difficult in any biomechanical data collection with people
- Page 36: "Despite its shortcomings, in vitro studies have the capability to provide much freedom to investigate function and behavior of the ACL."
    - What is meant by "freedom" in this case?
- Page 36: "From this standpoint, it can be argued that gait analysis is the only way available today to determine the kinematics and kinetics during activity to cause non-contact ACL injury."
    - Kinematics and kinetics of what? Kinematics and kinetics of muscle-bone-ligament are typically poorly defined by gait analysis.
    - Can whole body kinematics and kinetics (joint angles, net joint moments, etc.) truly show the cause or just a possible body position and external loading scenario for injury? Only if you actually measure an injury?
- Page 37: "A computational model of the knee joint is a graphical representation of the joint anatomy"

    - A computational model does not have to be graphically represented to be used (i.e., a computational model is not a graphical representation, but can be represented graphically)
    - "A computational model is a mathematical model in computational science that requires extensive computational resources to study the behavior of a complex system by computer simulation"
- Page 38: "The main advantage of musculoskeletal RB modeling is that it enables us to determine the forces in the muscles during activities implicated to cause non-contact ACL injuries"
    - Change "determine" to "estimate"
- Page 39: "This may exacerbate itself to much uncertainty in theories used for teaching clinical biomechanics"
    - What do you mean by "This may exacerbate itself to much uncertainty"? Lack of consensus on theories? How does a lack of concensus make things worse when teaching? The instructor would present both schools of thought.
- Page 40: "reductionist approach by focusing on a single factor or few factors due to small sample size."
    - Small sample sizes are not the reason for using methods that have a small number of variables.
    - If over 250,000 ACL injures are reported each year in the USA, a reasonable sample size for a study can be achieved
    - The cost of a large study may be the real problem
- Page 40-41: Various items in this proposed methodology are difficult to achieve:
    - That "close to injury joint kinematics" were achieved
    - Accurate "tibial displacement relative to femur"
    - Accurate "muscle tendon moment arms and lengths as well as muscle forces" for people that deviate from the model
    - Since the relative tissue/bone values that are modified by the AI could be wrong but create the desired output, having equivalent net joint moments, etc. does not necessarily validate the model … it just shows that equivalent net joint outcomes could be generated.
- Page 43:
    - "Nonetheless, this approach allows for virtual experimentation which has significant implication for cost reduction through reduced equipment needs, number of subjects required for testing, and also time for testing."
        - Virtual experimentation would reduce costs if a "perfect" model was built that answered all questions. Since this is not the case, costs are still present to verify if modelled outcomes apply well in the real world.
    - "In addition, one of the central aims of this proposed approach is to provide an enabling tool to better capture the many variables, constraints, unknowns, uncertainty, and variability entailed in the complex problem of predicting injury mechanisms and identifying risk factors of non-contact ACL injury."
        - How do you capture unknowns and uncertainty?
        - It is unclear how the tools helps with this sentence
    - What do you mean by "capture the interaction"

    - "This approach should also aim to provide information that can connect the cause and effect relationships between ACL loading, injury mechanisms, and risk factors of noncontact ACL injury."
        - What information would you be providing, for example
- Page 44: The first paragraphs is confusing. After rereading this many times, the author initially states that the model should provide various outcome measures but then states that the kinematic information to create this model is not available so this cannot be achieved?
    - "One approach to resolve this challenge may be to conduct parametric and sensitivity studies"
        - Studies of what parameters?
    - An unreasonable number of studies would be required to eliminate what does not produce an injury, with the objective of only leaving conditions that cause an injury. Therefore, this is not a viable approach
- Page 46: How can AI be used to "define a problem"
    - It is unclear how data from different people, different, injuries, and different conditions can be fused to generate useful information, using the proposed input data.
- The author states an approach but has not provided a sufficient rationale as to how this can be implemented in practice.
- Page 46: "A case was not proven that "the narrow focus of some studies and the dearth of standards and specifications in the field of biomechanics appear to have the effect of limiting progress". Past study methods and standards do not limit how a research can make an advance in the ACL field. Methodological and ethical issues are more likely the limitation.
- Page 47: Creators of ACL injury prevention programmes know how their system works. There is likely not one key element, so looking for such an element may not be warranted. The holistic approaches of avoiding vulnerable positions, increasing flexibility, increasing strength, including plyometric exercises in training, and increasing proprioception should be considered.

Paper 2

Text edits

- Page 58: Revise page numbers in paper reference
- Page 70: "compare rigid and deformable contact scenarios"
- Page 71: "multivariate function that"
    - "The Levenberg-Marquardt algorithm can be thought of as a combination of steepest decent and Gauss-Newton methods."
    - "This method was modified by Fletcher (Fletcher, 1971) to tailor the amount of dampening used at each iteration so as to"
    - "Powell (Powell, 1978) to solve an over constrained system of equations via least squares optimization"
    - "The authors used an AI technique, simulated annealing, to determine"
    - "Monte Carlo simulations were"
- Page 72: "Mclean et al. (Scott et al., 2004)"

- Check reference and spelling of McLean. If reference from Scott's paper, put year of the McLean work.
- Page 75: "determine if the model can be considered valid."

Content

- Page 61: What is "combined loading"
  - "Non-contact ACL injury is also a whole body phenomenon that is best analyzed by simultaneously addressing multiple risk factors of which neuromuscular control, joint kinematics and geometry, as well as, external forces that may be the most important."
    - Are the external forces the most important or other items in the sentence? How are you proving which is the most important (include reference, …)?
  - Video analyses are not necessarily qualitative. They may measure frequencies of injury situations, etc.
- Page 69: What is meant by "Intra subject variabilities may stem from technician performing experiments"?
- Page 70:
  - "A later study by Blankvoort et al. (Blankevoort and Huiskes, 1996) used the same mathematical model"
    - Which one, Blankevoort et al., 1991, Wismans et al., 1980?
  - "for usage in the model"
    - Which model?
  - "Blankvoort research group employed an optimization scheme to estimate the initial strains since no experimental data was available"
    - You said that the previous model was used in the last sentence?
  - I do not understand "experiments via the variation of the reference strains in the ligament". Are these other experiments on people?
- Page 72:
  - Monte Carlo methods are algorithms that randomly generate and retain the best solutions before going to the next search iteration."
    - This does not seem to be the case for Scott et al, 2008: "The Monte Carlo approach adopted within the current study necessarily considered each perturbed input parameter as independent from the next. In other words, for that N-dimensional space, we necessarily sampled input conditions from all corners of the hypercube. Adopting such an approach meant that some of the combined perturbed conditions would be highly unlikely in vivo, with performance of a successful sidestep being virtually impossible in these instances."
  - "Monte Carlo method is used primarily in this application to evaluate the probability of random outcomes of human movement."
    - This does not seem to be the case for Scott et al., 2008
  - "Monte Carlo simulation is an attractive tool since it allows researchers to study and predict risk of sustaining an injury before injury occurs."
    - This sentence is not supported by the reference

    - "However, simulated annealing is simply mentioned by the authors but the way the method is employed to answer the author's research question is not clear
        - Scott provides both the equation and reference for the simulated annealing approach
- Page 73: "whether sagittal plane knee loading during sidestep cutting could in isolation injure the ACL"
    - How is the injury isolated if the person is sidestep cutting and a load is applied?
- Page 74: "The AI technique is employed to orchestrate the fusion of the two quantitative study approaches in the MDO paradigm,"
    - What are the MDO study approaches?
- Page 74; It is unclear how clinical studies, interviews with athletes, video analyses will be used for validation
- Page 74: "An AI technique also enables one to capture the wide variability in movement patterns …"
    - AI can also generate a wide variety of incorrect results
- Page 75: "The external forces, muscle activation, and muscle forces at this specific lower extremity kinematic should …"
    - What do you mean by a "lower extremity kinematic"?
- Page 77: "It was shown that present challenges in non-contact ACL injury studies stem partly from the inability of existing study approaches to simultaneously capture numerous factors and parameters which are at play during ACL injury."
    - This was proposed, now shown (i.e., shown is usually associated with evidence, such as evidence that more factors and parameters improve clinical practice). Since error may increase with more parameters, we cannot assume that the final outcomes will be better for a particular method.
    - Based on this paper, the thesis should combine "biomechanical, environmental, anatomical and hormonal variables". The thesis does not include hormonal or environmental factors
    - "AI technique is better suited to address present challenges"
        - Better that OR?

Paper 3

Text edits

- Page 87:
    - "the relationship among sagittal plane body kinematics, knee power, knee work and peak GRFs."
    - "single-leg landings from platform heights of 20, 40, and 60 cm"
    - "Subjects also performed single-leg landings from a 40 cm height platform placed 30, 50 and 70 cm from the rear edge of a force plate"
    - Define first instance of VGRF, PGRF
- Page 88: "knee joint, two key factors"
- Page 90 "that hip external rotation strength had"
- Page 91: "Motion capture system (Vicon MX, Oxford Metrics, UK) consisting" to A seven camera motion capture system (Vicon MX, Oxford Metrics, UK) was used to collect …"

- Page 92: "were instructed to stand on a variable height landing platform (20, 40, and 60 cm)"
    - "All kinematic data and analog data were low-pass filtered using a second-order bidirectional Butterworth filter at 6 Hz and 20 Hz, respectively."
        - This sentence could be rewritten so that the reader does not have to reread the sentence to understand, due to the use of respectively. For example, "Kinematic data were filtered using a second-order bidirectional Butterworth filter at 6Hz and analog data were filtered at 20 Hz.
- Page 93: "correlations were also used to"
    - "finding of this study (Fig. 2) was that the horizontal"
        - No highlights/shading were show in Fig. 2.
- Page 97: "Our results corroborate these findings showing that by increasing ankle plantarflexion, there"
- Page 98: perhaps too short to allow the muscles surrounding the ankle and knee to respond."
- Page 99:
    - "Further, at an increasing landing height, hip and trunk flexion may be more appropriate for attenuating GRFs" both eccentric
    - "knee power and eccentric knee work were positively and significantly correlated to both peak VGRF"

Content

- Page 87: "more appropriate for jump landings"
    - You have shown that hip-trunk or ankle-knee strategies are used by the subjects, but not that these are the most appropriate.
- Page 90: "Although the above-mentioned studies reported valuable findings, they lack data concerning sagittal plane kinematics and kinetics of the ankle, knee, hip, and trunk at increased height and distance of landing"
    - Combining the studies covers a range of heights and they do report flexion/extension biomechanics
- Page 91:
    - Describe the identical shoes (brand, etc.)
    - Define the "customized marker protocol"
- Page 93:
    - If you are referring to the maximum VGRF, use this term instead of peak. A curve can have many peaks but only one maximum.
    - 0.8 s before VGRF is a long time, is this correct? The entire stance phase in walking can be shorter that this time. A quick check of the literature shows 50-70 ms for time from foot strike to maximum VGRF in a jump landing and the entire event is over within 0.5 s.
    - Using time as the basis for work calculations can create error, as opposed to event-based criteria, since timing between individuals varies
- Page 93:
    - Did you use 2D sagittal plane kinematics or 3D flexion-extension for the analysis? I is unclear why you would take 3D data and deconstruct this to 2D

sagittal plane analysis, especially since the leg typically rotates out of the sagittal plane during landings.
    - Correlations <0.7 are not high. Do you mean relatively higher that some other analysis? Typically, 0.2 to 0.4 Weak, low correlation (not very significant); 0.4 to 0.7 Moderate correlation; 0.7 to 0.9 Strong, high correlation; 0.9 to 1.0 Very strong
    - "knee work as determined at the time of peak VGRF"
        - Work is typically over a range and not at a single value. How was this calculated?
    - "The means and standard deviations of the sagittal plane body kinematics, knee power, and knee work"
        - Is this the mean and SD across all subjects? Please specify for text and figure captions.
    - "There were no significant relationships between peak VGRF and ankle or knee flexion; however, our results indicated significant correlations between both hip and trunk flexion and peak VGRF."
        - For which tests (vertical or horizontal)?
- Pages 94, 95:
    - In methods you indicated 6 different tests, landing from 20, 40, 60 cm and landing from 30, 50, 70 cm; however, the tables on page 94 only provide one set of means. Is this the overall mean for all trials?
    - Mean and SD for all subjects need to be shown for each test condition
    - In Figures and tables, state which test conditions are being displayed in the caption. All conditions have VGRF and PGRF values so you need to specify what the reader is seeing.
    - Without the data for each trial, I cannot tell from the scatter plots how each person varies between conditions.
    - Correlation matrix is stated but only one column of data is displayed.
- Page 96:
    - "Results of this study showed that ankle and knee flexion to be moderately and significantly correlated with peak PGRF"
        - 0.395 is a weak correlation
    - "Interestingly, no significant correlation between peak PGRF and hip flexion or trunk flexion was found."
        - The weak correlations are more interesting than the significance, significance only states that the results is likely not by chance. In these cases, the correlations are low but this result may just be by chance.
    - "It was also observed that both the eccentric knee power and eccentric knee work demonstrated a moderate to high negative correlation with both the peak VGRF ($r=0.493$, $p=0.037$ and $r=0.63$, $p=0.005$, respectively) and the peak PGRF ($r=0.63$, $p=0.005$ and $r=0.475$, $p=0.105$, respectively)."
        - 0.63 is moderate, not high
        - You stated negative correlations but the r values are positive
        - It will be easier for the reader to understand this statement if they can see the results for each condition in a table

- "Results of this study (see Fig. 1 and Fig. 2) support the findings of other studies that investigated a completely different event but demonstrated a significant correlation between peak GRF and risk of knee injury"
    - This study does not make a link between peak GRF and knee injury risk, and figure 1 and 2 only show a trend between greater GRF for higher and longer jumping distances, as previously known.
- "Our results showed that at increasing vertical heights, knee flexion was not correlated to peak VGRF and therefore may have little potential for reducing the risk of non-contact ACL injuries during single-leg landings."
    - This statement is not supported. Even though the six subject's used a different strategy for dealing with landing forces, this does not mean than bending the knee cannot be used as a strategy.
- "This does not corroborate the study by Stacoff et al. (Stacoff et al., 1988) which showed that the knee joint angle can be used to reduce the magnitude of the impact loads during landing."
    - This sentence should be reworded since the results indicate that the 6 subjects did not need to increase knee flexion at maximum GRF for the test conditions, but they could have use knee flexion to reduce impact loads if required.
- "However, our study is in agreement with findings of Faugenbaum et al. (Fagenbaum and Darling, 2003) who showed that factors other than knee flexion must significantly contribute to an increased risk of noncontact ACL injuries."
    - Since this study is not testing at an ACL injury level, the study results cannot be used to make a statement on increased risk of noncontact ACL injuries.
- "Moreover, it may be inferred from our findings that the ankle may not be effective for modulating peak VGRFs at increased height of jump."
    - I need to see the results across heights to evaluate this statement
- "Our study also showed that at increasing vertical height, an increase in hip and trunk flexion can significantly reduce peak VGRF and subsequently reducing the risk of non-contact ACL injuries"
    - Your study showed that a negative correlation existed between hip and trunk flexion and jump height. Therefore, hip and trunk flexion angles were smaller at increased heights. This does not support the statement
    - Secondly, the study did not look at the effect of using more trunk and hip flexion at a higher height to reduce VGRF. You would have had to have subjects perform a series of jumps at the same high height but with progressively more hip or trunk flexion and the see the effect on VGRF.
    - Lastly, peak VGRF was not significantly reduced at the higher heights (i.e., higher height, greater VGRF)

- Page 97:
    - "Even though there are no single-leg landing studies to draw comparisons"
        - A large number of studies on single leg landing report joint angles, for many heights. These can be used for comparison.
    - "these findings are in agreement with the literature that reported that increased hip and trunk flexion may reduce the risk of non-contact ACL injuries"

        - The results do not support this statement
    - "Forward trunk lean and increase hip flexion may place the body COM more anterior and could potentially decrease the contraction demand for the knee extensor muscles (i.e. quadriceps muscles), while increasing the contraction demands for the hip extensors (i.e., hamstrings muscles)"
        - You reported a significant positive correlation for knee moments and powers, so the results do not support this statement about reducing demands at the knee.
    - "at increased distance of landing, our study found that there is a statistically significant relationship between peak PGRF and ankle and knee flexion,"
        - The correlation between PGRF and angle flexion was not significant
    - "Our results corroborate these findings showing that by increasing ankle plantiflexion, there will be a reduction in peak PGRFs for landings performed at increased landing distance"
        - The results do not support this statement. PGRF is greater at longer distances. Since ankle dorsiflexion was defined as positive, the ankle was dorsiflexed at max PGRF. Also see previous statement about study methodology to verify this statement.
    - "an increase in distance of landing led to a reduction in peak PGRF"
        - The results showed an increase in maximum PGRF with increasing distance (figure 2). Values are increasing negatively, due to the force plate axis convention.
- Page 98:
    - "Perhaps the answer can be found in the time to perform such tasks. For increasing landing heights the time to perform the single-leg landing is very short, perhaps to short to allow the muscles surrounding the ankle and knee to respond."
        - No timing results were presented to support this statement. These results must be included in the paper. How much less time with increasing height? How does this difference relate to motor control times?
        - Which time are you referring to, from airborne to landing, from ground contact to maximum force?
        - Without evidence, this statement should be removed.
    - "Future studies by the authors will endeavor to employ a larger sample size as well as to account for the effect of gender during single-leg landing from varying heights and distances."
        - This sentence is typically in the conclusions
    - "The landing strategy recommended here and discussions stemming from this study"
        - A landing strategy was not recommended in the paper
        - No discussions from this study were reported
    - "Further in vivo and in vitro studies using a large and varied subject population, as well as computer simulation studies are needed to solidly validate our findings, and determine whether the landing strategy found actually reduces ACL loading in vivo."

        - This sentence can be removed since it is not related to the study (i.e., no ACL-injury inducing findings were reported in the study that would need to be validated)
    - "This study investigated the relationships between varying vertical height, horizontal distance, and peak GRFs during single-leg landing and further related these findings to risk of non-contact ACL injury"
        - The study results were not successfully related to ACL injury
- Page 99:
    - "Further, at increase height of landing, hip and trunk flexion may be more appropriate for attenuating GRFs"
        - This statement is not supported by the results
        - More appropriate that what other strategy?
    - "while at increase distance of landing, ankle and knee flexion may have more potential to attenuate GRFs"
        - This statement is not supported by the results
        - More potential that what other strategy?
    - "Hence, the biomechanical strategies for decelerating the body in the vertical and horizontal directions may be different."
        - You can make a stronger statement since, for your subjects, there was a clear difference between vertical and horizontal landing strategies
    - "In addition, both eccentric knee power and eccentric knee work was positively and significantly correlated to both peak VGRF and peak PGRF"
        - PGRF knee work was not significantly correlated

Paper 4

Text edits

- Page 104: "explain the higher number of injuries among females"
- Page 106: "To undertake this, a relationship between three non-contact ACL injury risk predictor variables (maximum VGRF, maximum PGRF, maximum knee abduction moment) and selected single-leg landing biomechanical variables were studied"
- Page 107: "The seven camera motion capture system (Vicon MX, Oxford Metrics, UK) collected marker trajectories at a sampling rate of 250 Hz."
- Page 111:
    - "$F(1,9)=20.91$, $p<0.01$, partial η 2=0.699 with ankle plantarflexion angles."
    - "More specifically, there was a significant height×distance interaction Greenhouse-Geisser adjusted"
    - "interaction Greenhouse-Geisser adjusted $F(3.31, 29.79) =3.73$, $p=0.019$; partial η 2=0.293 for peak VGRF, $F(2.17, 19.54) =4.13$, $p=0.029$; partial η 2=0.315 for knee internal rotational moment, $F(2.58, 112\ 23.22)=3.15$, $p=0.05$, η 2=0.26 for hip flexion, and $F(2.98, 26.79)=3.90$, $p=0.02$, η 2=0.30 for trunk flexion."
        - This sentence is difficult to read. Please revise.

Content

- Page 104:

- "The number of non-contact ACL injuries is higher among females; however, there is no conclusive evidence that this is due to biomechanical differences between genders. One explanation is the lack of studies investigating gender differences in whole body biomechanics during single-leg landings from increasing vertical heights and horizontal distances."
  - The evidence is strong that males and females have biomechanical differences for the target activity related to landing (many studies, some with large samples). The statement should be revised
- "reaction force (PGRF) for males (r=–0.85, p=0.004),"
  - Assuming that the 6 males are the same people as in paper 4, why is the r value different?

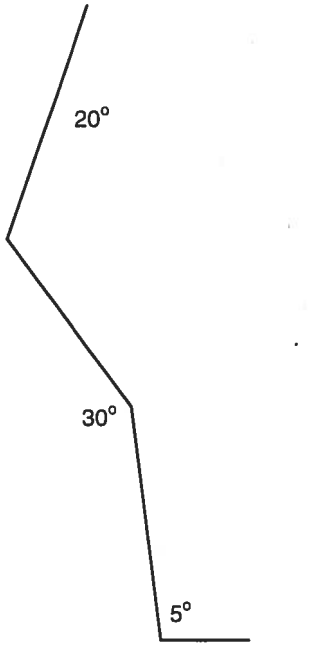
- Page 105:
  - "while nearly significant and moderately correlated to peak PGRF for females (r=–0.542, p=0.13)"
    - 0.13 is not nearly significant at the $p<0.05$ level
  - "while no significant interaction was observed for distance and gender"
    - Why would you anticipate an effect for distance and gender? Both gender group performed the same methods and therefore move the same distance.
  - What are "ankle plantiflexion angle gender effects"
  - "There are few single-leg landing studies in the literature"
    - Many single-leg landing studies are in the literature, I made a quick search and found over 16 studies so far in 2011. The review paper by Schmitz, 2007 has 34 references just on the topic of gender differences
  - "Further, most single-leg landing studies only report data on the knee joint kinematics and kinetics."
    - A sufficient number of studies report results for other joint, therefore this sentence should be revised
  - "Hence, peak PGRF may also predict the risk of sustaining a non-contact ACL injury"
    - Alternatively, it may be the increased in resultant force that is the issue and not an isolated increased in the PGRF vector. Greater VGRF also causes an increase in eccentric knee extensor moments.
- Page 107:
  - Please make same changes to Procedures as outlined in the Paper 3 comments
- Page 109:
  - "ACL injury risk predictor variables and various selected dependent variables"
    - Please list the variables
  - "current study did not produce the characteristics distinct biomodal GRFscurve commonly reported during double-leg landing (Dufek and Bates, 1990; Zhang et al., 2000)"
    - The GRF curves were consistent with single leg landing curves form the literature. The sentence should be revised to compare with single leg landing and not double leg landing, since this is a single leg landing study.
    - This sentence should also be moved to the discussion since a literature comparison is not needed in the results.

- "The demands of the current tasks studied resulted in a smoother increase to GRF"
  - Smoother than what?
- "Therefore, the biomechanical comparisons of double leg landing with single leg landing results in the literature may be limited due to the differences exhibited by the two tasks."
  - Comparing single and double leg landing is not the focus of this paper, so these sentences should be removed.

- Page 111:
  - "Follow up tests with the three non-contact ACL injury risk predictor variables"
    - No follow-up tests were described in the methods
  - "Females had significantly less ankle plantiflexion angle than males"
    - What stats were used for this result?
  - "while a moderate but near significant negative correlation for females ($r=-0.542$, $p=0.131$)"
    - 0.131 is not near significant at the $p<0.05$ level
- Page 112:
  - Table 2 must provide mean and SD for all outcomes discussed in the results and discussion.
- Pages 113-114:
  - Table 2: The results for males are strange since the ankle is more plantarflexed as the height increases but dorsiflexed (or less plantarflexed) at the longer horizontal distances. This typically means that the tibia is behind the ankle when the foot is flat (assuming maximum VGRF does not occur until the heel contacts the ground). Since the knee is approx. 28-32 degrees flexed and trunk is 17-21 deg flexed, this puts the body in a strange position (see below). The dorsiflexed ankle angle for the women seems more understandable.
    - As in the figure below, cofg would be behind the base of support and without arm motion recovery of balance would be difficult
    - Since the SD for ankle angles are quite high (1-5x higher than the mean) does outlier data account for these differences?
    - This should be discussed
  - Table 3: Why are the correlations for males greater than in paper 3?
    - Are all trials across all conditions used for these correlations?
  - Table 5: Are these correlations for all conditions and all subjects?
  - Data are duplicated in tables 5 and 7
- Page 115:
  - See ankle angle comments above
  - "Our results revealed that females exhibited significantly lower ankle plantiflexion"
    - Females are dorsiflexed (Table 2)
  - "which offers a possible explanation to the higher number of non-contact ACL injuries among females,"
    - Since you are analyzing the ankle angle at maximum VGRF, this point does not relate to the mentioned studies, which are considering ankle angle at initial contact

- "Hence, a reduction in peak PGRF may be realized by increasing ankle plantiflexion during single-leg landing which subsequently may reduce the risk of non-contact ACL injury"
  - PGRF did not decrease as distance increased, so this point is not supported.
- "Perhaps an increase in plantiflexion permits more time to distribute the impact forces and better enables the musculature to absorb these forces as demonstrated by the following studies"
  - This study only looked at the maximum VGRF instance in time so this statement is not supported by the study.
- "and implies that horizontal distance of landing—often ignored in most studies—is an important variable"
  - This force component is not ignored, please rephrase
  - Importance for what? ACL indicator? I would expect that the resultant force is the main item, with this force being larger if the person jumps farther (higher, longer, or longer and higher)
- "Our results also suggest that knee abduction moment can be modulated by increasing trunk flexion"
  - This statement how you arrived at this statement. Please expand on this and support with the project outcomes.
- "Given there are no single-leg landing studies to draw comparisons"
  - Many single leg landing studies exist for comparison. Please use these.
- "Perusal of the main effects of height and distance correlated with selected biomechanical variables (see table 7) revealed that increased knee flexion angle, hip abduction angle, knee power, knee work and horizontal distance between foot and the body COM, as well as, an accompanying decrease in vertical distance between foot and the body COM, is associated with reduction in peak VGRF, thereby demonstrating the possibility of these variables to reduce the risk of non-contact ACL injury.
  - This statement has many problems.
  - VGRF increased (i.e., not reduced)
  - Variables increased as VGRF increased, so how can you prove that these variables reduced risk (i.e., variables increased but VGRF still increased)
- "Without studies to draw comparisons"
  - Other single landing studies exists that can be used for comparison
- "In addition, our results revealed that at increased in plantiflexion angle, knee flexion angle, knee power, knee work, and horizontal distance between foot and the body COM, as well as, an accompanying decrease in vertical distance between foot and the body COM is associated with a reduction in peak PGRF.
  - Same issues as with VGRF
  - PGRF either increased with greater horizontal distances or was almost unchanged (h60d30,h56d50)
- "knee abduction moment and the biomechanical variables tested suggesting that knee abduction moment may be less a predictor of risk of non-contact ACL injury compared to peak VGRF and peak PGRF for single-leg landing tasks."

        - This may be due to the female subject sample for the study. Did the subjects have moderate-large q-angles?
        - If the subjects did not land in an abnormal knee abducted position, then you cannot test to see if knee abduction moment is a good indicator since the moments would be larger if the person lands with more knee abduction.
        - Your subjects may have been sagittal plane dominant but some people have larger frontal plane deviations (see literature on females landing)
    - "Our findings (see table 7) reveal a significant and high positive correlation between both peak VGRF and peak PGRF, and the vertical distance between the foot and body COM supporting the findings in the literature …"
        - The COM results are for vertical COM distance should be discounted since this distance only changed by 3 cm (96-99 cm) and this difference is within the error of identifying COM. Therefore, the data shows that vertical COM could have no real-world effect, even through there was a correlation.
        - Also, you did not measure the range of COM motion so the study cannot show if COM was lowered.
    - "Due to the lack of studies examining body kinematics and kinetics over increasing heights and distances, we are unable to fully compare our results with the literature."
        - If you make a table with the results from the literature, you will have information for many variables over a range of heights and distances, for many subjects.
    - "relatively small sample size (N=11),"
        - Comparison size is even smaller (n=5 for females)
    - "The landing strategy recommended and discussions stemming from this study"
        - See paper 3
    - "Lower plantiflexion angles was observed for females"
        - Females were dorsiflexed, which will allow the ankle to progress forward to attenuate forces. The problem would be if they landed with 0 degrees and no movement occurred.



Paper 5

Text edits

- Page 122: "While contributing to an understanding"
- Page 128:
  - "uses the anthropometric data measured for each subject to scale the MSM (Rasmussen, 2005). An optimization-based method …"
  - "taken, firstly, we compared"
  - "This information is presented in an on-off timing curve (Fig. 2) that shows when the measured and predicted muscles activity goes above (turns on) and below (turns off) a 20% threshold during single-leg landing. Secondly, …"
- Page 129: "using the subject-specific MSM, example provided in Fig. 3, after completing"
- Page 131: "Separate 3×3 two-within-one-between subject repeated measures ANOVAs were conducted"

Content

- Page 122:
  - "Results revealed no significant gender differences in the musculoskeletal variables tested except peak VGRF ($p=0.039$), as well as, knee and hip axial compressive force ($p=0.05$, and $p=0.032$, respectively)."
    - In paper 4 no significant difference was found for VGRF but the 3 subjects that were selected for paper 5 show a significant difference. Therefore, the selection of these 6 subjects is questionable.

        - Since axial load is related to VGRF, these significant differences could also be attributed to subject selection from your population sample.
    - "Our results showed no significant association between quadriceps force and risk of ACL injury"
        - This makes sense since you did not have injury inducing loads during testing
    - "Within the limitations of the subject-specific MSMs, our findings indicate that musculoskeletal variables studied are not the sole determinants to ACL injury."
        - It is difficult to make a statement on ACL injury based on the methodology
- Page 124:
    - Check references for Shin (2007,2009, 2011), Mokhjtarzadeh, Yeow, et al. (2010), Bulluck (2010 – Masters Thesis) for models and single leg landing
        - Since loads at 60 cm are non-injury inducing but higher than the lower heights, are the lower height trials necessary if the focus is on ACL injury?
        - Bulluck performed a similar study so his results should be used in the comparison. Especially since quadriceps and hamstring results were different.
    - "The ability of body kinematics or lower extremity muscles to attenuate the GRFs upon landing from a single-leg requires further investigation."
        - This broad statement is not supported. Many studies exist in the literature, what aspect of force attenuation is lacking?
    - What do you mean by "elaborate internal joint loads"?
- Page 125:
    - Weight and height matching of the males and female populations does not necessarily improve the methods since females are typically shorter and lighter than males.
    - What shoes were worn (brand, etc.)
- Page 128:
    - Define AMS
    - IDA is not used later in the text so this abbreviation can be removed
    - "Secondly, the joint forces and moments measured in vivo at the knee joint during gait and reported in the literature were compared with predicted knee joint forces and moments"
        - Include reference to this gait literature. Was this walking gait? Both males and females?
        - This paragraph can be rewritten to more clearly show the methods. For example,
            - "Secondly, the joint forces and moments measured in vivo at the knee joint during gait and reported in the literature were compared with predicted knee joint forces and moments (Table 1). The MSMs were driven with the individual subject's knee joint forces and moments obtained from single leg drop landing trials.
    - "Based on these findings and recognizing variability in body anthropometry between studies, it appears that the developed subject-specific MSMs tends to

reproduce the trends in internal forces and moments well while systematically overestimating the joint reaction forces."
    - Which findings? The literature review?
    - No trend for most measures in table 1 (i.e., only one comparison value)
    - Anybody results are higher than the range for Fz and Fx only, therefore they do not reproduce the trends and did not show a systematic overestimation (Fy was not higher)
    - What are the Anybody results? Mean of all 6 subjects?
  - "The latter can be controlled in the MSMs by adjustment of muscle moment arms, but in the interest of reproducibility it was elected to not pursue this option."
    - What is "the latter"?
    - So what was done to correct the models? Was the error left in place?
- Page 128:
  - "The time at which peak VGRF occurred was used to determine the selected musculoskeletal variables."
    - This sentence indicates that the VGRF time in seconds was used to select the variables used in the analysis. Since this is probably not the case, please revise.
- Page 130:
  - Figure 2:
    - The activity and start-end events are unclear.
    - Including event timing in the figure would help the reader (foot strike, etc.).
- Page 132:
  - "Nonetheless, the trends in the predicted muscle activations (thin lines) sets in reasonably close in time as the measured muscle activations (fat lines), therefore demonstrating fairly good agreement between model prediction and experimental data"
    - What do you mean be trends?
    - The comments of "reasonably close" and fairly good" do not support the use of the defined model for further study. Tibialis anterior and rectus femoris are quite different and the timing/duration factors could adversely affect the model's ability to predict forces.
  - It is not clear where Figure 3 shows the interaction with the environment
- Page 133:
  - Figure 3: It is questionable to state that the model has been validated due to the errors.
  - A table of means and SD for main measures is required (maximum VGRF, Hip & Knee axial forces, max PGRF, max Proximal tibial shear force, etc.), with male and female results separated.
    - Later in the document, Table 3 provided some data, but only for the entire sample. The male and female results are needed separately since this is the analysis that is presented.
  - "Between genders, females had significantly lower peak VGRF, as well as, knee and hip axial compressive forces."
    - What statistic was used for this posthoc analysis?

- Page 134:
  - Figure 4
    - Revised to only show the data from foot strike onwards (inactivity from 8-85% is not needed for these graphs).
    - Y-axis scaling should be the same for males and females
    - In a printed version, I cannot distinguish the curves by the legend. PDF enlargement to 300% was sufficient.
- Page 135:
  - "From descriptive statistics –not presented– one can observe an almost linear increase"
    - Since these statistics were not presented, I cannot observe this increase.
  - "Follow up test with this variable and the two non-contact ACL injury risk predictor variables revealed no significant correlation."
    - What was this followup-test. Please provide the methods and results or remove from the paper.
  - Is height the jump height or the subject's height?
  - "Results revealed no significant height×gender, height×distance or height×distance×gender interactions (Table 1).
    - Table number is incorrect in paragraph
- Page 137
  - Figure 5: The y-axis label is muscle force; however, the EMG data was not scaled to force but to a % of maximum voltage. How did these data become converted to BW?
- Page 138:
  - "This study showed that single-leg landings did not produce the characteristic bimodal VGRF curve commonly reported for double-leg landings"
    - Yeow (2010) had similar shaped curves in his study that tested both single and double leg landing.
    - The reason could be that you did not allow arm movement on landing. Therefore you are correct that the difference was related to the task but it should be mentioned that you are dealing with a "single leg landing without arm movement" and not a typical single leg landing.
  - "This finding is important as it elucidates the unique nature of single-leg landing studies whose findings cannot be compared with double-leg landing studies"
    - Revise as per previous comment
  - "Females may have experienced lower VGRF upon single-leg landing because of their lower quadriceps to hamstring muscle activity resulting in higher energy absorption and subsequently lower VGRF."
    - You cannot determine energy absorption since the analysis was at one point in time (VGRF). To make a conclusion, you should reanalyze the data and see if the females have greater energy absorption over the entire limb loading task.
  - "Existing single-leg landing studies in the literature … do not include the effect of the muscles"

        - See Shin (2007,2009, 2011), Mokhjtarzadeh, Yeow, et al. (2010), Bulluck (2010 – Masters Thesis)
    - "Our findings support this argument showing no significant association between quadriceps muscle force and the two possible non-contact ACL injury risk predictor variables."
        - It is difficult to say that the results from this study contribute to the ACK injury risk factor discussion since the subjects were not in an injury situation
    - "Our results also corroborate other studies (Pandy and Shelburne, 1997; Yu and Garrett, 2005) that found hamstring muscles did not reduce ACL loading when knee flexion angles are small."
        - An analysis of hamstring muscles and knee angles was not presented in the results.
    - "Our results showed that increasing gastrocnemius muscle force protects the ACL by reducing both peak VGRF and peak PTASF (Table 3b)."
        - Table 3b shows a negative correlation, so gastrocnemius muscle force decreased as the VGRF increased. This does not prove that the gastrocnemius protects the ACL.
    - "Even though the predicted absolute values of muscle activations as well as knee joint forces and moments are overestimated, the trend agreement between …"
        - No trend data were provided that proves this statement
    - "Given the number of variables that can affect the ACL loads in vivo, our findings suggest that musculoskeletal variables are only one facet to non-contact ACL injury biomechanics, and factors such as hormones, strength training, fatigue or a combination of all these, may perhaps better explain the gender disparity in the incidences of non-contact ACL injury."
        - It is unclear how the study methods and results support this statement.

Discussion

- Page 146: "To address this concern, the authors presented a novel study approach that — once developed— can enable researchers to capture many of the parameters and extreme conditions simultaneously involved during non-contact ACL injuries"
    - Interestingly, the recommended method from the first two papers was not followed in this thesis.
    - Since the MDO method was not used in this thesis, does this show that the MDO method would be nice but may not be practically to implement.
- Page 149:
    - "Since there were no studies investigating body kinematics and kinetics during single-leg landing from increasing vertical heights and horizontal distance"
        - Studies exist for increasing heights, but not horizontal distance
    - "Investigations of how the body kinematics can attenuate these applied forces may provide insights into the ability of the body to reduce the loading seen at the ACL"
        - The studies did not look at how forces are attenuated (i.e., analysis was performed at maximum GRF)

- "Furthermore, at increase height of landing, hip and trunk flexion may be more appropriate for attenuating peak VGRFs, while at increase distance of landing, ankle and knee flexion may have more potential to attenuate peak PGRFs "
  - Use of arms should also be considered (i.e., does lack of arm motion affect trunk position (balance, etc.)?)
- "This does not corroborate the study by Stacoff and co-workers (Stacoff et al., 1988) that showed that the knee joint angle could be used to reduce the magnitude of the impact loads during landings."
  - Less knee flexion from the study sample does not mean that the Stacoff results were incorrect, just that some other method was used. This statement should be reworded.

- Please see previous comments on each paper for revisions to this section

Conclusions

- Comments in this thesis review should be considered when revising the conclusions.

FACULTÉ DES ÉTUDES SUPÉRIEURES ET POSTDOCTORALES

FACULTY OF GRADUATE AND POSTDOCTORAL STUDIES

THESIS EXAMINER'S REPORT

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NAME OF STUDENT	STUDENT NUMBER	DOCTORAL THESIS	MASTER'S THESIS
Nicholas Ali	5033260	☒	☐

DEGREE	ACADEMIC UNIT
Ph. D.	School of Human Kinetics

TITLE OF THESIS

"Predicting Risk Factors of Non-Contact Anterior Cruciate Ligament Injuries During Single-Leg Landing"

NAME OF THESIS SUPERVISOR	NAME OF THESIS CO-SUPERVISOR
Dr. Gordon Robertson	Dr. Gholamreza Rouhi
NAME OF EXAMINER	**DEADLINE FOR SUBMISSION OF REPORT**
Dr. Michel Labrosse	December 19, 2011

PART A: EVALUATION / Tick off the choice that best describes your evaluation of the thesis.
PART B: COMMENTS / Provide your comments for each of the topics listed.
PART C: RECOMMENDATION FOR A PRIZE / Indicate your decision and complete the attached form if recommending thesis for a prize.
PART D: SIGNATURE / Sign and date the form
PART E: DOCUMENTS / Return necessary documents.

CRITERIA

DOCTORAL THESIS: The thesis must constitute a significant contribution to knowledge, embody the results of original investigation and analysis by the student and be of such quality as to merit publication.
MASTER'S THESIS: The thesis should demonstrate that the candidate is able to work in a scholarly manner and is acquainted with the principal works published on the subject of the thesis. Insofar as it is possible, the thesis should be an original contribution.

VERDICT

1	☐	**The thesis is accepted for the defence.** • The thesis meets the evaluation criteria listed above. • Required changes are limited to correcting occasional grammatical or spelling errors, formatting problems or to minor redundancies or omissions (e.g., transitional paragraphs, notes).
2	☑	**The thesis is accepted for the defence but must be revised AFTER DEFENCE.** • The quality of the presentation is acceptable and the necessary revisions will not have an impact on the defence. • During the defence, the jury will determine which revisions are necessary and who will be responsible for ensuring they have been completed and for approving the thesis.
3	☐	**The thesis cannot be accepted for the defence and must undergo extensive revision BEFORE DEFENCE to ensure it meets the above criteria.** • There are problems with the interpretation of results or the theoretical or methodological approach, but the thesis may meet the criteria if substantial changes are made. • The presentation of the thesis is still not acceptable (numerous grammatical or spelling errors, evidence of carelessness, etc.). In this case, the thesis is returned to the candidate to complete the required revisions, corrections and changes. The candidate must submit a revised version of the thesis to the examiners. The examiners must judge the changes satisfactory before the thesis can proceed to the defence stage.
4	☐	**The thesis still fails to meet the standards required for the degree.** • The work was not done in accordance with established methodology employed by the discipline. • The thesis does not exhibit the candidate's capacity to meet the scholarly standards required. • Even with extensive revision, the thesis would not meet the standards required for the degree. In this case, the candidate may be asked to withdraw from the program.

NOTE: Your feedback will have an impact on how the candidate prepares for the defence, the dean's decision if the jury is divided and the awarding of prizes. Please be sure to complete Section B regardless of your verdict.

Please provide your comments on each of the topics below in a separate document. If the thesis is accepted for the defence (see verdicts # 1 and # 2, above), your comments will be sent to the candidate and the thesis supervisor without reference to your identity. If major revisions are required before the defence (see verdict # 3, above), a signed copy of your comments will be provided to the student, the supervisor, as well as to all members of the jury and the chair of the academic unit.

→ UNDERSTANDING OF THE SUBJECT MATTER
→ CONTRIBUTION OF THE THESIS TO ADVANCING KNOWLEDGE
→ RESEARCH METHODOLOGY
→ ANALYSIS OF RESULTS AND VALUE OF CONCLUSIONS
→ ORGANIZATION, WRITING STYLE AND PRESENTATION OF MATERIAL
→ REVISIONS CONSIDERED NECESSARY IN ORDER FOR THESIS TO BE ACCEPTED
→ GENERAL COMMENTS

Your comments and explanations are extremely important and will:

- help the student prepare for the defence or make necessary revisions to the thesis (if revisions are required before the defence, a signed copy of your comments is provided to the candidate, the thesis supervisor, as well as to all members of the jury and the chair of the academic unit);
- allow the dean of FGPS to make an informed decision if the jury is divided; and
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Do you recommend this thesis for a prize?

☐ YES – Please complete the attached NOMINATION FOR THESIS PRIZE form.
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The absence of a reply will be considered a NO.

DATE Dec 7, 2011 SIGNATURE Michel Labrosse

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FÉSP / FGPS 2011-04-07

(M. Michel PADROSSE

Predicting risk factors of non-contact anterior cruciate ligament injuries during single-leg landing

Understanding of the subject matter

The candidate shows a thorough understanding of the literature as well as the experimental and simulation aspects related to non-contact ACL injuries.

Contribution of the thesis to advancing knowledge

The candidate's main contribution is to show unambiguously, based on an extensive literature review, that non-contact ACL injuries are multifactorial, not just with regards to biomechanics, but also anatomy, physiology and training. The candidate then goes on to propose a potentially all-encompassing approach to better understand the mechanisms leading to injuries, so as to come up with better training regimens to avoid them. The candidate pieces together a big picture based on current technologies and methods; however, the proposed approach is extremely computer intensive and no attempt is made to demonstrate its feasibility in reasonable computational times. The candidates then sets out to look at non-contact ACL injuries at a much smaller scale of complexity while still considering several factors simultaneously (even those often unaccounted for in other studies, such as trunk motion). Specifically, the candidate experimentally investigates body kinematics and dynamics during single-leg landing from various heights and distances. This in itself constitutes another new and valuable contribution. The candidate then applies computational simulation methods to determine the major muscle loads, again another valuable contribution. Overall, the topic of non-contact ACL injuries benefits from the work done by the candidate, although it is clear that a quantitative, validated unifying injury scenario still remains to be proposed.

Research methodology

The research methodology used by the candidate combines extensive use of the literature, as well as experimental and computational simulation means. It is adequate and corresponds to the expectations of a doctoral thesis. While the sample size for the experiments is small, the results achieve statistical significance (for the population segment tested) and perhaps more importantly, partially illustrate the multifactorial analytical approach proposed by the candidate.

Analysis of results and value of conclusions

The results are mostly properly described and analyzed throughout the dissertation. Clearly, the most interesting material with regards to analysis of experimental data is contained in Papers IV and V. However, there is some discontinuity in the results shown in both papers, although these results were assumedly obtained from the same set of experiments. This will deserve explanations during the oral defense and will likely justify revisions of the dissertation.

Organization, writing style and presentation of material

The organization and writing style of the material are acceptable, but would benefit from serious polishing and rewording/shortening of many unduly long and complex sentences. Many typos were also spotted. Many figures, graphs and tables are too small or too crowded, a problem that needs to be addressed.

Revisions considered necessary in order for the thesis to be accepted

See sections above. Revisions related to these issues are strongly recommended, but do not affect the acceptance of the thesis.

General comments

The candidate addressed a rich and complex topic, and put together a study representing a reasonable amount of work. Paper IV essentially repeats Paper III and goes further. Therefore, one should consider the deletion of Paper III for conciseness. A synthetic view of the non-contact ACL injury mechanism is still to be proposed, but the candidate has made interesting strides toward this goal.

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FACULTY OF GRADUATE AND POSTDOCTORAL STUDIES

THESIS EXAMINER'S REPORT

uOttawa

L'Université canadienne
Canada's university

NAME OF STUDENT	STUDENT NUMBER	DOCTORAL THESIS	MASTER'S THESIS
Nicholas Ali	5033260	[x]	[ ]

DEGREE	ACADEMIC UNIT
Ph. D.	School of Human Kinetics

TITLE OF THESIS

"Predicting Risk Factors of Non-Contact Anterior Cruciate Ligament Injuries During Single-Leg Landing"

NAME OF THESIS SUPERVISOR	NAME OF THESIS CO-SUPERVISOR
Dr. Gordon Robertson	Dr. Gholamreza Rouhi
NAME OF EXAMINER	**DEADLINE FOR SUBMISSION OF REPORT**
Dr. Daniel Benoit	December 19, 2011

INSTRUCTIONS FOR EXAMINERS

PART A: EVALUATION / Tick off the choice that best describes your evaluation of the thesis.
PART B: COMMENTS / Provide your comments for each of the topics listed.
PART C: RECOMMENDATION FOR A PRIZE / Indicate your decision and complete the attached form if recommending thesis for a prize.
PART D: SIGNATURE / Sign and date the form
PART E: DOCUMENTS / Return necessary documents.

PART A: EVALUATION

CRITERIA

DOCTORAL THESIS: The thesis must constitute a significant contribution to knowledge, embody the results of original investigation and analysis by the student and be of such quality as to merit publication.
MASTER'S THESIS: The thesis should demonstrate that the candidate is able to work in a scholarly manner and is acquainted with the principal works published on the subject of the thesis. Insofar as it is possible, the thesis should be an original contribution.

VERDICT

1	[ ]	**The thesis is accepted for the defence.** • The thesis meets the evaluation criteria listed above. • Required changes are limited to correcting occasional grammatical or spelling errors, formatting problems or to minor redundancies or omissions (e.g., transitional paragraphs, notes).
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4	[X]	**The thesis still fails to meet the standards required for the degree.** • The work was not done in accordance with established methodology employed by the discipline. • The thesis does not exhibit the candidate's capacity to meet the scholarly standards required. • Even with extensive revision, the thesis would not meet the standards required for the degree. In this case, the candidate may be asked to withdraw from the program.

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PART B: COMMENTS

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→ UNDERSTANDING OF THE SUBJECT MATTER
→ CONTRIBUTION OF THE THESIS TO ADVANCING KNOWLEDGE
→ RESEARCH METHODOLOGY
→ ANALYSIS OF RESULTS AND VALUE OF CONCLUSIONS
→ ORGANIZATION, WRITING STYLE AND PRESENTATION OF MATERIAL
→ REVISIONS CONSIDERED NECESSARY IN ORDER FOR THESIS TO BE ACCEPTED
→ GENERAL COMMENTS

Your comments and explanations are extremely important and will:

- help the student prepare for the defence or make necessary revisions to the thesis (if revisions are required before the defence, a signed copy of your comments is provided to the candidate, the thesis supervisor, as well as to all members of the jury and the chair of the academic unit);
- allow the dean of FGPS to make an informed decision if the jury is divided; and
- allow the FGPS selection committee to choose recipients of prizes and medals.

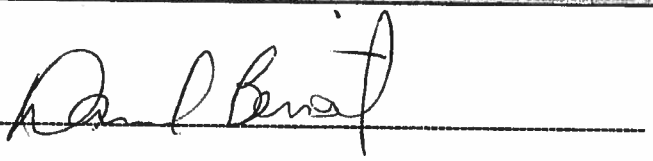
PART C: RECOMMENDATION FOR A PRIZE

Do you recommend this thesis for a prize?

☐ YES – Please complete the attached NOMINATION FOR THESIS PRIZE form.
☒ NO

The absence of a reply will be considered a NO.

PART D: SIGNATURE

DATE Dec/6, 2011 SIGNATURE 

PART E: DOCUMENTS

Please return all documents by email to fssrecherche@uOttawa.ca or by fax to 613-562-5437 and send the originals in the enclosed self-addressed envelope to:

Assistant to the Vice-Dean, Research & Graduate Studies
Faculty of Health Sciences
Roger Guindon Hall
451, Smyth Road Room 3028
Ottawa ON K1H 8M5

FÉSP / FGPS 2011-04-07

Dr Daniel Benoit

Evaluation report summary for Nicholas Ali.

This thesis fails to meet the standards for a Ph.D. degree for a number of reasons, including but not limited to :

1. <u>The thesis does not constitute a significant contribution to knowledge and the analysis by the student is not of such quality as to merit publication.</u>
    - Note: although 2 literature reviews are published, neither is in a journal particularly related to the subject matter presented. Neither describes the methodology used to decide on the chosen articles. Neither uses any criterion to evaluate the included articles. As reviews of literature, they are not significant contributions.
    - I would not consider the final three manuscripts (III, IV and V) merit publication due to, among other things described further on, methodological concerns such as a lack of sufficient subjects (manuscripts III, IV, V). Paper V also lacks model validation (although it is stated many times in the thesis that this has been done) and uses a male musculoskeletal model to represent females (it is simply a scaled down size of model, as pointed out to me by the co-authors on the paper). To my knowledge, this paper has also been rejected outright by the journal it was submitted to, although it is still referred to as submitted in the thesis.

2. <u>The work was not done in accordance with established methodology employed by the discipline. (below is a non-exhaustive overview of some of my concerns)</u>
    - Results of the experimental manuscripts are inconclusive and not valid due to lack of sufficient subjects in all three manuscripts. No power analysis was reported but, based on my experience in the discipline, at least 2 to 3 times the number of subjects are required in manuscripts III and IV, likely more would be required for paper V.
    - The paper V purports to evaluate gender differences using musculoskeletal models, however (for example), only three subjects of each gender are evaluated and the model used on both genders is in fact a male model...in other words, the females are in fact treated as height and weight adjusted males. The claim in the manuscript that the model has been validated is not supported by the results.
    - Although the use of a repeated measures ANOVA is questionable in all three experimental manuscripts due to the number of subjects evaluated, it is particularly dubious in paper V where only three subjects are in each group, not to mention that no correction for related measures is considered, nor is the post-hoc analysis described.

- The external validity of manuscripts III and IV is limited, as stated by the authors themselves.
- The internal and external validity of paper V are limited.

3. <u>The thesis does not exhibit the candidate's capacity to meet the scholarly standards required. (below is a non-exhaustive overview of some of my concerns)</u>
    - The methodological concerns noted above indicate that the candidate lacks the scholarly standards from a technical (methodological) point of view.
    - Information contained in the thesis is misleading since at least two of the declared conference presentations were never presented.
    - Letters from the editors of the journals with manuscripts Under Review are not provided. This is an essential first step since, to my knowledge, at least one of those manuscripts has in fact been rejected outright and this is not noted in the thesis.
    - The two accepted manuscripts are reviews of literature in journals that are not reflective of the article content and, although accepted, are of limited value due to a less than rigorous or exhaustive methodology which is not coherent with systematic reviews.
    - Manuscripts IV-V lack statistical power, adequate methodological descriptions, and inappropriate use of statistical measures.
    - The student repeatedly states in the thesis that a lack of multifactoral research exists in the study of ACL injuries yet many of the studies sited are multifactoral in their approaches, in particular those that combine kinematics and kinetics or musculoskeletal models... the student seems to dismiss these in order to justify this thesis, instead of acknowledging what has been done and how it contributes to the field of study and does not seem objective. Then, in the end, the study uses similar methodologies to form his conclusions as the papers previously criticised

4. <u>Even with extensive revision, the thesis would not meet the standards required for the degree.</u>
    - As a body of work there are too few subjects, weak methodological and statistical approaches and overreaching conclusions beyond the evidence suggested by the results in all three experimental papers.
    - The two published manuscripts are of limited contribution and published in journals which are not discipline-related.

5. UNDERSTANDING OF THE SUBJECT MATTER

The candidate states:

"*To the best of the author's knowledge no study to date has investigated gender differences during single-leg landing from increasing vertical landing heights and horizontal landing distances.*" Meanwhile, there exists a great body of knowledge about the biomechanics and associated risk factors of single leg landing under various experimental and simulated conditions, including vertical landing heights, for example.

"*Further, there are no MSMs in the scholarly literature that has been developed, validated and applied to single-leg landing in the literature.*" Untrue, there are… not to mention that the student does not fill this purported void with the thesis.

"*Further, the majority of studies in the literature pertaining to single-leg landing do not account for the effects of whole body movement on ACL loading.*" Untrue, there are… not to mention that the student does not fill this purported void with the thesis.

"*In addition, to the author's best knowledge, the current literature demonstrates that there are no proposed multifactorial study approaches aimed at fusing existing non-contact ACL injury study approaches into a single environment using an AI technique.*" This statement is unclear since it is unclear what the author is referring to as an AI environment. Two thing are certain: (1) many studies have used multifactorial models and approaches to investigate non-contact ACL injuries; (2) if the candidate refers to the approach he has taken in Paper-V, then it is again untrue and others have done this before, whereas if he is referring to some new innovative approach, the candidate has not done it in this body of work nor elucidated what that approach would be.

"*These models are driven by kinematics and external forces.*" The candidate is speaking of musculoskeletal models but fails to recognise the body of literature which uses EMG driven models, which are in fact driven by internal forces, as muscles are internal force generators to the system.

6. CONTRIBUTION OF THE THESIS TO ADVANCING KNOWLEDGE

Very limited since the validity of the studies (both internal and external) is questionable. In particular, a lack of subjects make the results highly speculative and the statistical approaches inappropriate. There is little innovation aside from modifying jump height and distance, and the two reviews of literature are not exhaustive or systematic and seem biased.

It must also be stated here that paper V uses a commercially available software (ANYBODY) to build the model and analyse the data, not a custom model developed by the student. This is not clear in the thesis.

7. RESEARCH METHODOLOGY (this is a non-exhaustive summary)

Paper I:

- The methodology described for the initial review of the literature seems initially exhaustive, however when I used one of the 4 search terms provided by the authors I turned up 3743 articles whereas the authors found 813 articles total; furthermore no criterion for triage down to the 147 articles cited is given by the authors. Considering the strong focus on modeling in the paper, at least one search term should include the word model or simulation, for example.
- One example of a lack of depth to the discussion: "*Mathematical programming and the Monte Carlo method (Blankevoort and Huiskes, 1996; McLean et al., 2003) are the current often used optimization approaches employed to study ACL mechanics. Although both mathematical programming and Monte Carlo methods have demonstrated their usefulness and effectiveness as a research tool, there are much more advanced and robust AI techniques; namely, taboo search, simulated annealing, genetic algorithms, and artificial neural networks.*" In fact, "simulated annealing" is currently one of the most popular and widespread methods in musculoskeletal modeling…

Paper II:

- It is not quite clear if this paper is a review of literature or opinion-piece on how to investigate ACL injury. To me, it is more of an opinion piece and is more suited to be in a thesis discussion then as a publication since it lacks objectivity.
- It is not clear why the authors would chose this journal as it does not seem to be related to the field being investigated.
- Similar concerns with regards to the approach and criterion used to select papers as paper 1 above.
- This paper would serve as an introduction to the thesis, but in my opinion is not an in depth review.

Note that while I believe it is a good idea to try and publish one's thesis, papers one and two seem to be the review of literature portion of the thesis as opposed to original scientific contributions to the literature.

Manuscripts III and IV:

- The purpose of these manuscripts is good.
- The actual measurement techniques (i.e.: in laboratory techniques) in these manuscripts are acceptable.
- There is a lack of subjects, putting the statistical analysis and validity in doubt. I believe that this statement by the authors is worth noting: "*this study is limited by a*

small sample size; hence our results may not be representative of the general population and may not be conclusive. While we cannot conclude the general male population would exhibit sagittal plane body kinematics, knee power, and knee work as determine in our study for single-leg landings, we were able to show that the relationships found have a good fit in terms of r2 and p values for the six subjects tested." The r-square and p values are questionable since there were not enough subjects to perform these tests in the first place...as a PhD thesis, this is unacceptable. These two manuscripts are better described as pilot projects or incomplete projects.

- Even if one considers the correlation values reported, the relatively low levels of correlation make conclusions difficult to support (a statistically significant correlation does not necessarily mean an important one...)
- The emphasis in the two reviews of literature is to avoid a reductionist approach when studying the ACL injury, yet these manuscripts do exactly that.
- It is unclear if the subjects from paper III were used in paper IV and this should be stated.
- A table containing the dependant variables for each independent variable would be beneficial.
- The choice of dependant variables is not clear "*various selected dependant variables*" is the only information given.
- No consideration of the inter-dependence of the selected variables is given and no correction of the probability coefficient is considered for these variables
- Given paper IV, paper III seems redundant.

Manuscript V:

- Too few subjects (3 males and 3 females) to extract meaningful conclusions. Similar to manuscripts III and IV, this manuscript is a good beginning, but not and end product.
- There is a lack of model validation: the authors somehow conclude that the musculoskeletal model is valid based on EMG activations which are not reflective of the predicted model-driven activations, with no objective comparisons...this makes no sense to me.
- The model used in this paper is not novel nor is it developed by the candidate: it is an application of a musculoskeletal model from the ANYBODY Software repertoire, which requires the user of that model to adjust the model to the input data.
- The model used for the female subjects is a scaled version of the male model, not a gender-specific model. As such, it cannot take into account physiological and anatomical differences between the sexes, even though the purpose of the paper is to evaluate these things.

8. ANALYSIS OF RESULTS AND VALUE OF CONCLUSIONS

- The statistical analysis of the results is questionable due to the small sample sizes in all manuscripts
- The validity of the model used in paper V is not established; the use of a male musculoskeletal model to represent females is questionable, in particular given the anatomical and neuromuscular sex-related differences highlighted by the candidate, for example
- The value of the conclusions was accurately put into doubt by the candidates own statements regarding a lack of sample size for manuscripts III and IV.
- The value of the conclusions for paper V are in doubt due to a lack of sample size and the above mentioned lack of model validation and use of a male model to represent females.

9. ORGANIZATION, WRITING STYLE AND PRESENTATION OF MATERIAL

- The organization of the manuscripts is very good.
- The writing style is good.
- Presentation of the material is good.

10. GENERAL COMMENTS

In its present form, this body of work does not represent a Ph.D. thesis. Paper status and conference presentations must also be clarified by the candidate.

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FACULTY OF GRADUATE AND POSTDOCTORAL STUDIES

THESIS EXAMINER'S REPORT

uOttawa
L'Université canadienne
Canada's university

NAME OF STUDENT	STUDENT NUMBER	DOCTORAL THESIS	MASTER'S THESIS
Nicholas Ali	5033260	[x]	[ ]

DEGREE	ACADEMIC UNIT
Ph. D.	School of Human Kinetics

TITLE OF THESIS

"Predicting Risk Factors of Non-Contact Anterior Cruciate Ligament Injuries During Single-Leg Landing"

NAME OF THESIS SUPERVISOR	NAME OF THESIS CO-SUPERVISOR
Dr. Gordon Robertson	Dr. Gholamreza Rouhi
NAME OF EXAMINER	**DEADLINE FOR SUBMISSION OF REPORT**
Dr. Graham E. Caldwell	December 19, 2011

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PART A: EVALUATION

CRITERIA

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PART C: RECOMMENDATION FOR A PRIZE

Do you recommend this thesis for a prize?

☐ YES – Please complete the attached NOMINATION FOR THESIS PRIZE form.
☒ NO

The absence of a reply will be considered a NO.

PART D: SIGNATURE

DATE December 18, 2011 SIGNATURE Graham Caldwell

PART E: DOCUMENTS

Please return all documents by email to fssrecherche@uOttawa.ca or by fax to 613-562-5437 and send the originals in the enclosed self-addressed envelope to:

Assistant to the Vice-Dean, Research & Graduate Studies
Faculty of Health Sciences
Roger Guindon Hall
451, Smyth Road Room 3028
Ottawa ON K1H 8M5

FÉSP / FGPS 2011-04-07

Doctoral Thesis External Examiner Report

December, 2011

Candidate: Nicholas Ali
University of Ottawa

Examiner: Graham E. Caldwell, Ph.D.
University of Massachusetts Amherst

Graham Caldwell

Title: Predicting risk factors of non-contact anterior cruciate ligament injuries during single-leg landing

Examiner's Report

General comments: In this thesis, the candidate examines single-leg landings from various vertical height and horizontal distance combinations, and attempts to relate kinematic and kinetic variables from these landings to anterior cruciate ligament (ACL) loading and injury risk. The candidate presents his work in a series of 5 papers (Chapters 2 to 6), with Chapter 1 serving as an overall Introduction and Chapter 7 as an overall Discussion. Papers 1 and 2 are reviews of the current literature concerning ACL biomechanics and injury, papers 3 and 4 describe the experimental studies that used a rigid body inverse dynamics approach to investigate the single-leg landings, and paper 5 describes the development and use of a musculoskeletal model (MSM) for estimating internal forces that cannot be measured or computed with the rigid body approach.

Strengths:

- ***Important clinical issue*** – ACL injuries are an important clinical issue, and for some unknown reason, female athletes have much higher injury rates compared to males.

- ***Use of MSM techniques*** – In the latter half of the twentieth century, the most common biomechanics modeling technique used rigid body models and inverse dynamics to analyze segmental motion and compute the underlying resultant moments and reaction forces that act at individual joints. More recently, musculoskeletal models (MSMs) have become more commonplace, permitting the estimation of forces within specific tissues (muscle, ligament, and bone-on-bone forces) that could not be performed with inverse dynamics. The candidate uses both rigid body models and MSMs in this thesis.

- ***Knowledge of ACL literature*** – The 2 review of literature chapters (papers 1 and 2) demonstrate a good knowledge of the literature concerning ACL biomechanics and injury risk.

Weaknesses:

- ***Lack of anatomical description of the knee structures and the role of the ACL within this overall structure*** – Given the thesis topic, early in the thesis it would be appropriate to include a detailed description of the knee anatomy and function, including clear diagrams of the ACL, its location, and its role within the complete milieu of ligaments, muscles, cartilage and bones that form the knee structure. This description (and accompanying diagrams) should make very clear why jumping from various heights and distances might be expected to cause ACL injuries, thereby helping to build the rationale for the experimental work to follow.

- ***Duplication of review of literature material in papers 1 and 2*** – Although I understand that papers 1 and 2 were written for separate publication in academic journals, there is much overlap between the 2 chapters. From the perspective of the thesis document, I think the review of literature would be much better served if written as a single chapter. The 2 submitted papers could be included as Appendix material.

- ***Possible lack of awareness concerning use of optimization techniques such as simulated annealing and genetic algorithms in the biomechanics literature*** – While reading the Introduction and paper 1, I was intrigued by the author's contention that present study approaches are inadequate and that he was proposing to use new state-of-the-art artificial intelligence (AI) tools and techniques. However, much of the text was vague and lacking details. It was not until near the end of paper 1 (page 45) that I discovered that the AI tools include optimization techniques such as simulated annealing and genetic algorithms. Although the author may (or may not) be correct in saying that there are no non-contact ACL injury papers that use these techniques, simulated annealing is a commonly used optimization technique in the biomechanics literature, and has been for over 10 years. The tone and vagueness of the author's writing implies that these are new techniques that are at the heart of a new, integrated study approach that is better than those presently used in biomechanics research. I disagree, and wonder if this is poor writing, a difference in terminology associated with the author's background training, or is the author unaware that these techniques are commonly used in biomechanics research?

- ***Inconsistency between "gap" study described in papers 1 and 2 with subsequent experimental papers 3, 4, 5*** – In papers 1 and 2, the author's viewpoint on currently used study approaches is clear. A main point of both papers 1 and 2 is that ACL injuries are multi-faceted, and current approaches that try to elucidate the role of a single risk factor are inadequate. In paper 2, the author describes a better approach that would incorporate multiple risk factors within a unified research approach. Because these papers formed the literature review that was to identify "gaps" in the literature and therefore provide the rationale for the author's doctoral work, I was expecting that the subsequent experimental and modeling efforts would follow this multi-faceted approach. However, papers 3 and 4 use the typical biomechanics approach that the author had criticized in papers 1

and 2. Even in paper 5 where the author describes a MSM, it is used to further analyze the same conditions (and same experimental data?) as in paper 4, and not in the manner described in papers 1 and 2.

- ***Lack of lateral and medial jump directions in papers 3, 4, 5*** – It is clear from the literature that one situation that puts the ACL at risk is movements that include a component in the medial-lateral direction in addition to anterior-posterior motion, such as "cutting" maneuvers during running. Why did the author choose to vary vertical height and anterior-posterior distance in the landing conditions, but not medial-lateral distance?

- ***Incomplete description of results in papers 3, 4, 5*** – The landing experiments that form the basis for papers 3, 4 and 5 will have produced a wealth of kinematic and kinetic data that describe the time-varying changes that occur as subjects prepare and execute their landing. However, the author has chosen to describe and present very little of these data. In the first of these papers (chapter 4), there are no time series data reported at all, making it difficult for the reader to appreciate how the subjects reacted to the different landing conditions. The only data reported are peak vertical and posterior GRF, plus values for some joint variables at the time of these peak GRF occurrences. One variable was knee joint work, which is calculated by integrating the knee joint power curve over some time of interest (which is not described). How are we to interpret these single value data? Do these variables also reach their peak at the time of peak VGRF or PGRF? It is inappropriate to use that single value to represent joint motion during landing execution. For example, having a knee flexion value of –33 degrees (Table 1, page 94) at the time of peak VGRF does NOT indicate the degree of knee flexion during the landing phase; it is only one measurement from a time series of knee flexion angles. These data form the basis for correlations with VGRF (Table 2), and the correlations are then interpreted with statements such as (page 96) *"Our results showed that at increasing vertical heights, knee flexion was not correlated to peak VGRF and therefore may have little potential for reducing the risk of non-contact ACL injuries during single-leg landings."* This is incorrect, as the author has not assessed the amount of knee flexion in each landing, only the knee flexion angle that occurred at peak VGRF. This "single value at time of peak GRF" is repeated in papers 4 and 5, and can lead to incorrect conclusions on any variable assessed. There are some time series data shown in papers 4 and 5, and some bar charts of gender-specific muscle forces in paper 5. In my opinion, more of these data should be reported in all 3 experimental papers.

- ***Incorrect interpretation of at least some correlation data in papers 3, 4, 5*** – At least some of the correlation data in these chapters have been interpreted incorrectly. For example, in paper 3, peak PGRF data are plotted as a function of horizontal distance jumped in Figure 2, page 95. Notice that on the vertical axis, the PGRF values are all negative, which is an indication that the posterior direction has been assigned to be negative, while the anterior direction is positive. Further, notice that as you scan across the graph from lower horizontal distances (30 cm) to

higher ones (50 and then 70 cm), the PGRF values INCREASE in magnitude (from ~-0.6 to -0.8 for the mean). Because of the negative values assigned to the posterior direction, this forms a negative slope on the graph, and the author reports this negative correlation as *"The other significant finding of this study..."* (page 93, in Results). However, the author mis-interprets this negative slope when he states on page 97 *"Our results ..... there will be a REDUCTION in peak PGRFs for landings performed at increased landing distance"*. This is particularly troublesome for the GRF data, as this statement of reduced horizontal force with increased jumping distance runs contrary to Newtonian physics: with increased horizontal jump distance, the horizontal take-off and landing velocities MUST increase, and the horizontal landing impulse (force X time; area under the force-time curve) MUST increase to bring the horizontal velocity to zero upon landing. One would expect the peak PGRF values to also increase in magnitude (as they do), although it is possible for the impulse to increase but not the peak PGRF. This level of mechanics knowledge should be well within the capability of a doctoral student in biomechanics. The author should carefully check the interpretation of ALL correlations, especially ones that include positive or negative signs that indicate direction (e.g. force vector components, joint angular velocities, joint moments).

- ***Incomplete description of subject population(s) in papers 3, 4, 5*** – In paper 3, there are 6 male subjects. In paper 4, there are 6 male subjects and 5 female subjects. Are these the same male subjects in both studies? Are the data from paper 3 and 4 from the same experimental data collection, or from 2 different data collections? In paper 5, there are 3 male and 3 female subjects. Are these a subset of the subjects in papers 3 and 4? Why is EMG data only reported for the 6 subjects In paper 5? If any of the subjects / data are the same in the 3 papers, this should be noted when describing the subjects in papers 4 and 5.

- ***Poor statistical power in papers 3, 4, 5 due to small subject numbers*** – In the 1970s and 1980s, It was normal for biomechanics studies to have relatively few subjects due to the tedious and time consuming data analysis procedures (cinefilm methods with hand digitization, force plate data that needed to be carefully synchronized, and all data reduction and analysis performed with custom written software). However, in the past 20 years we have seen the advent of automated motion capture systems which seamlessly integrate time synchronized kinematic, kinetic and EMG data, and off-the-shelf 3D analysis software (e.g. Visual 3D) and MSM software (e.g., OpenSim, AnyBody). With this improvement in data handling we have seen larger numbers of subjects in biomechanics studies, which brings greater statistical power. Why are so few subjects used in the studies described in papers 3 and 4, and particularly in paper 5? Did the author perform a statistical power test *a priori* that suggested such low subject numbers?

- ***Incomplete description of MSM in paper 5*** – In paper 5, the author uses subject-specific MSMs to predict the forces in internal body tissues. However, the model is not described in sufficient detail, with only general statements used such as *"The GaitFullBody MSM was ... individualized for each subject"* and *"... the model is*

made subject-specific by employing a length mass fat scaling algorithm that uses the anthropometric data measured for each subject to scale the MSM". What data are used as inputs to the model? What anthropometric measures were used in the scaling? How many muscle models are included in the model? Are differences in individual subject joint strengths (measured with a dynamometer), or muscle morphology (from MRI or ultrasound) included in the subject-specific models? Were the muscle model force-velocity, force-length and elastic characteristics subject-specific? Was the force plate data used as input to the model, or did the model include a foot – floor interface that would generate GRFs as model outputs? How did the MSM generate its muscle model activity timing as seen in Figure 2? Was there an objective function that was optimized? Were there constraints on the solution? How were they imposed, as "hard constraints" or as penalty terms in the objective function? Which optimization algorithm was used (e.g. simulated annealing)? A much more complete description of the MSM and how it was tailored to each subject is needed.

- ***Use of gait data in model "validation"*** – In paper 5, the author describes the use of *"gait data collected during our study"* for purposes of validation. What gait data were collected (none was described in the experimental procedures)? Was it for the same subjects? Running? Walking? What was the progression speed? Was the gait at constant speed, or were the subjects accelerating or decelerating? Were the foot – floor interface parameters the same for gait as in single-leg landing? Should they be? And even if the gait model results were compared to literature values as in Table 1, how do we know the MSM will be valid in an impact situation with sudden deceleration such as in single-leg landing? In the absence of a comparison between model and experimental data from the single-leg landing trials, I am unconvinced that the model should be considered validated as the author states. How well do model kinematics match experimental kinematics? How well do model GRFs match subject GRFs? Did the author perform a sensitivity analysis to see which model parameters have the largest impact on the model results?

- ***Omission of knee ligaments (including ACL) in MSM*** – In papers 1 and 2, the author champions the use of MSMs that will allow the estimation of internal forces acting on tissues within the body, important data that cannot be measured due to ethical considerations, and cannot be computed by standard rigid body inverse dynamics models. In paper 5 the author describes the use of a MSM, but I was very surprised to find that the MSM did NOT include the ACL, which of course is the main topic of the doctoral thesis. Why was the ACL (and the other 3 major knee ligaments) omitted from the MSM? Given the title and topic of the thesis, what was the rationale for leaving the ligaments out of the model? Surely the force (stress) and strain that the ACL undergoes during the landings would be a valuable addition to the thesis?

- ***Data for males and females not reported separately in paper 5*** – In paper 5, the data and correlations in Table 3 are reported for all 6 subjects in aggregate, even though the purpose is to compare the male and female groups. The separate male

and female data should also be reported, and indeed are the critical data needed to compare between male and female responses.

Understanding of the subject matter: The candidate seems to understand the subject matter, as the review papers 1 and 2 display good knowledge of the extant literature concerning ACL injury. He has also chosen an important topic to study.

Contribution of the thesis to advancing knowledge: This is difficult to judge until the data in papers 3, 4 and 5 are described in more detail.

Research methodology: The motion capture, force measurement and EMG data collection techniques used by the author are well established in the biomechanics community, as are the use of rigid body inverse dynamics models and musculoskeletal models. Due to lack of written detail, it is difficult to know whether the musculoskeletal models are really "subject-specific" as the author claims, and it is difficult to know how well these models represent the subject movements during the single-leg landing tasks. I do believe that the studies are under-powered due to low subject number.

Analysis of results and value of conclusions: As described in the **General Comments** section above, the data in papers 3, 4 and 5 are not described in sufficient detail. This makes it impossible to fully understand the results of the experiments, and therefore the value of the conclusions. In my opinion, there are incorrect interpretations of at least some of the correlation data presented, leading to some incorrect conclusions.

Organization, writing style and presentation of material: The organization of the thesis is logical, beginning with review(s) of the literature as a preamble to the experimental work. The writing style itself is fine, although in many cases the author is vague and does not include sufficient detail. As described in the **General Comments** above, I have major issues with the lack of detail in the material presented in papers 3, 4 and 5. I also think that chapter 7, currently titled "Discussion", would be better described by a title such as "Summary and Future Studies". As it stands now the chapter is not really an integrated Discussion of the thesis findings, but rather a serial summary of each of the 5 papers, followed by recommendations for future research. If it is to retain its current title, the chapter needs substantial revision to include integration of the important aspects of the different papers that is not present in the separate chapters themselves.

Revisions considered necessary in order for thesis to be accepted: Please refer to the **General Comments** section above for issues that, in my assessment, should be addressed in some manner before the manuscript can be evaluated for acceptance.

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PLEASE SUBMIT THIS FORM TO THE FACULTY OF GRADUATE AND POSTDOCTORAL STUDIES.

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Nicholas Ali	5033260	☑ THÈSE DE DOCTORAT *DOCTORAL THESIS* ☐ THÈSE DE MAÎTRISE *MASTER'S THESIS*

UNITÉ SCOLAIRE - *ACADEMIC UNIT*
School of Human Kinetics

TITRE DE LA THÈSE - *TITLE OF THESIS*
PREDICTING RISK FACTORS OF NON-CONTACT ANTERIOR CRUCIATE LIGAMENT INJURIES DURING SINGLE-LEG LANDING

NOM DU DIRECTEUR OU DE LA DIRECTRICE DE THÈSE - *NAME OF THESIS SUPERVISOR*
D. Gordon E. Robertson

UNITÉ SCOLAIRE - *ACADEMIC UNIT*
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EN MA QUALITÉ DE DIRECTEUR/DIRECTRICE DE THÈSE, J'AI EXAMINÉ CETTE THÈSE ET JUGE QU'ELLE MÉRITE D'ÊTRE SOUMISE AU JURY.

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DATE

SIGNATURE

Lise Daze

From: Lise Daze
Sent: Thursday October 20, 2011 9:09 AM
To: 'Gholamreza Rouhi'
Cc: Gordon Robertson; hksecr; FSS Recherche
Subject: RE: Doctoral thesis deposit/evaluation

Hello Dr. Rouhi,

Thank you so much for this confirmation, it's very appreciated.

Best,
Lise

-----Original Message-----
From: Gholamreza Rouhi [mailto:grouhi@uottawa.ca]
Sent: Wednesday October 19, 2011 10:15 PM
To: Lise Daze
Cc: grouhi@uottawa.ca; Gordon Robertson; hksecr; FSS Recherche
Subject: Re: Doctoral thesis deposit/evaluation

Thanks for your email, Lise. This is to confirm that I'm acting as Mr. N Ali's PhD thesis, and also approve that his thesis can be submitted to the examiners.
Regards,

--
Gholamreza Rouhi, PhD
Assistant Professor, Faculty of Biomedical Engineering, Amirkabir University of Technology, Tehran, Iran

> Hello Dr. Rouhi,
>
> We have received a signed Statement form to confirm Mr. Nicholas Ali's
> thesis submission from Dr. Robertson to the Faculty of Health Sciences.
>
> I have been informed that you are out of the Country but still acting
> as Co-Supervisor for Mr. Ali, if this the case, we would need you to
> confirm that you approve of the thesis for its submission simply by
> responding to this message with a confirmation.
>
> Best regards,
> Lise
>
>
>
> Lise Dazé
>
> Adjointe scolaire, thèses et de la diplômation Academic Assistant,
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PREDICTING RISK FACTORS OF NON-CONTACT ANTERIOR CRUCIATE LIGAMENT INJURIES DURING SINGLE-LEG LANDING

BY

NICHOLAS ALI

PhD Thesis submitted to the
Faculty of Graduate and Postdoctoral Studies
in partial fulfillment of the requirements for the
Doctor of Philosophy at the Faculty of Health Science
School of Human Kinetics
University of Ottawa

Abstract

The literature suggests that body kinematics and musculoskeletal differences are major factors contributing to the high disparity in non-contact ACL injury rate between genders. The literature also indicates that the incidence of non-contact ACL injury predominates during single-leg landing sports such as basketball, soccer, and handball. Despite this, there are few studies investigating kinematic or musculoskeletal differences between genders during single-leg landing from increasing vertical heights and horizontal distances. The objective of this study is threefold: first, conduct a gap study identifying the barriers to predicting mechanisms and risk factors to non-contact ACL injury. Second, propose a new approach that can address many of the challenges encountered in many existing non-contact ACL injury study approaches. Finally, whilst determining whether or not gender differences explain the higher rate of ACL injuries among females, identify and correlate the biomechanical and musculoskeletal variables significantly impacted by gender, vertical landing height, and/or horizontal landing distance and their interactions to various ACL injury risk predictor variables during single-leg landing. Experiments using male and female subjects, biomechanical analysis using Visual3D, and musculoskeletal modeling using AnyBody Modeling System were approaches used to explore these objectives. Salient findings from this dissertation includes but are not limited to, non-contact ACL injury that occurs during single-leg landing is mutifaceted entailing many factors which cannot be captured in any one existing ACL injury study approach. Non-contact ACL injury during single-leg landing may not be gender specific. Both height and distance of landing increase the risk of non-contact ACL injury during single-leg landing. Body kinematics during single-leg landing may not be the sole determinant in attenuating ground reaction forces and consequently risk of ACL injury. The hamstring and gastrocnemius muscles were determined to strain shield the ACL while the quadriceps was found to have no significant effect on risk of ACL injury during single-leg landing. Within the findings and

limitations of this study the knowledge garnered from this research can aid in tailoring future studies so as to enable more robust non-contact ACL injury prevention protocols.